



FLIGHTWEIGHT ELECTRO-MAGNET SYSTEMS

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Outline

- ◆ **Introduction**
- ◆ **Aluminum Coil Design**
- ◆ **Aluminum Coil Test Results**
- ◆ **Low T_c Superconducting Coils**
- ◆ **Flux Pump**
- ◆ **Future of High T_c Coils**

Introduction

➤ **Need for Lightweight Electromagnets**

- ◆ **Ion thrusters and Hall thrusters already conceived for the future.**
- ◆ **Magneto-plasma Dynamic Thrusters and Pulsed Induction Thrusters could become more conceivable.**

➤ **Overall Program to produce lightweight magnets:**

- ◆ **Produce a lightweight non-superconducting large bore magnet operating in a pulsed mode.**
- ◆ **Produce a lightweight low temperature superconducting large bore magnet operating in a continuous mode to determine characteristics and shielding required for high temperature confinement of fast ions.**
- ◆ **Produce a lightweight high temperature superconducting large bore magnet operating in a continuous mode.**
- ◆ **Develop low mass, low energy power supplies for the two superconducting magnets.**

➤ **Design Considerations - 77 K Coil**

- ◆ Light weight - Aluminum
- ◆ Low Electrical Resistance - Aluminum
- ◆ Low Magneto-resistance - Aluminum

➤ **Design Considerations: Low Temperature Superconducting Coil**

- ◆ Well Characterized - Nb₃Ti
- ◆ Economical and Commercially Available - Nb₃Ti
- ◆ Known Methods for Superconducting Electrical Connections to operate in persistent current mode.
- ◆ Use to determine cryogenic shielding environment required through laboratory testing.

➤ **Flux Pump Power Supply**

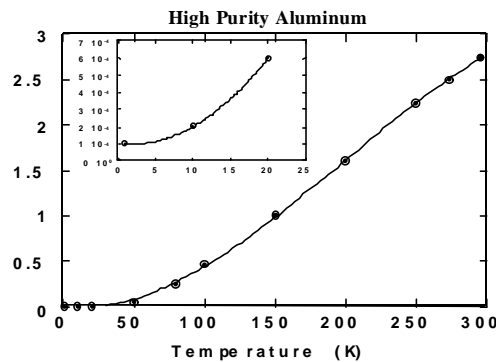
- ◆ Light weight
- ◆ Low power consumption continuous operation.

➤ **Design Considerations: High Temperature Superconducting Coils**

- ◆ Operate at near persistent current mode between 20 and 25 K.

Materials Characteristics for Three Construction Phases

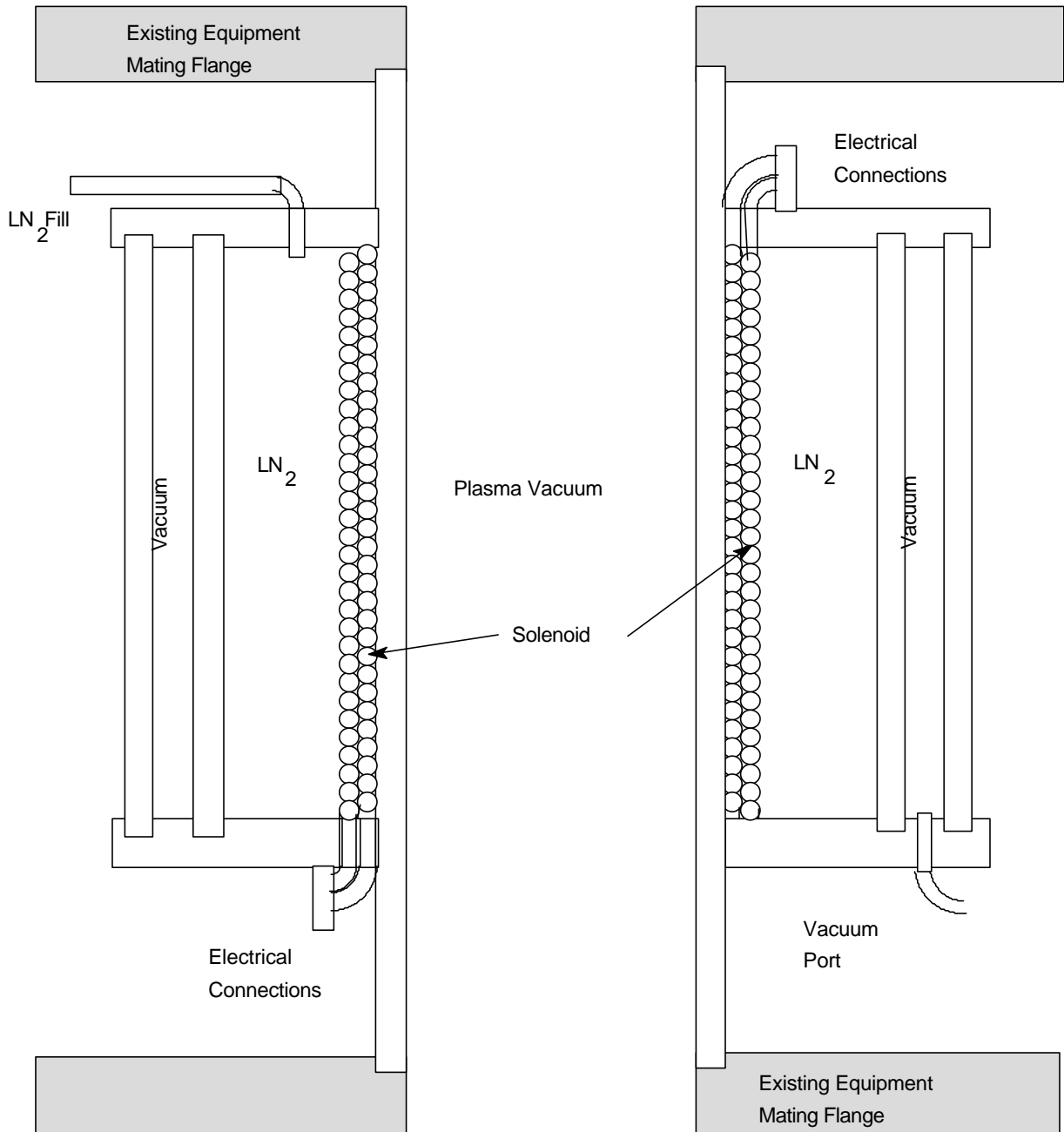
- The overall resistance of aluminum should be greatly reduced from its room temperature value at 77 K reducing power requirements. For successful operation the magneto-resistance should be low at the magnetic fields at which it operates.



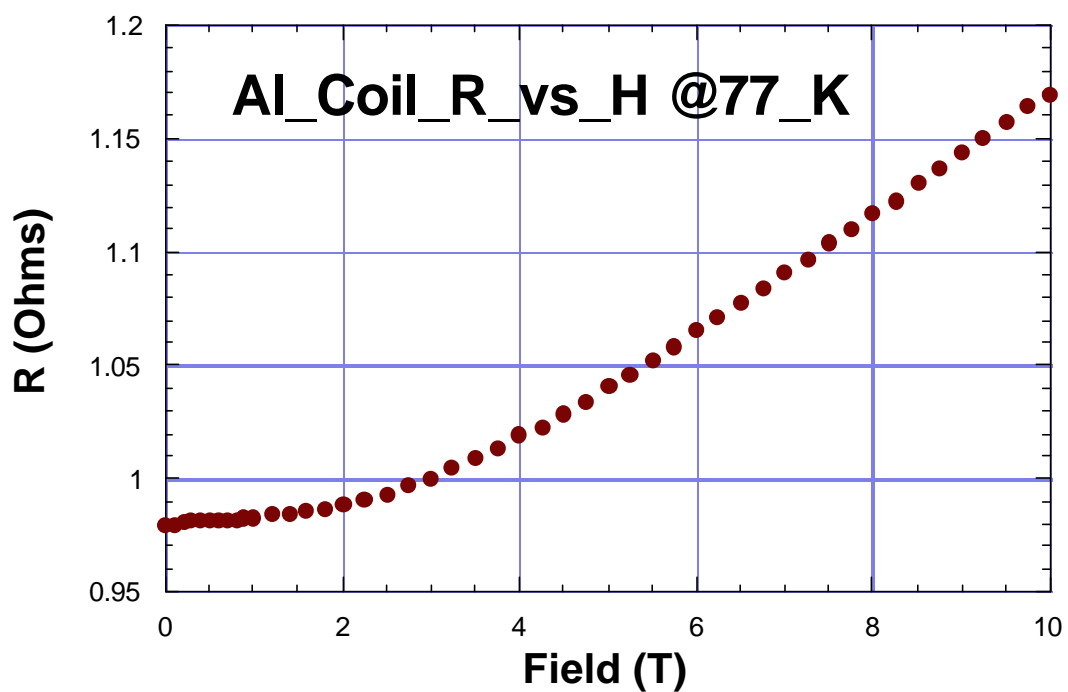
- At 4 K Nb₃Ti is the material of choice because it is readily available in wire form and has been used successfully for the construction of superconducting magnets operating to 5 T at 4 K for many years. Special consideration to shielding and cryogenics design will be given in this part of the project.
- For operation at 20 - 25 K BiSrCaCuO is the suggested material because high critical current wires of this material can be purchased commercially and

will operate in a self produced field of 2 T at 20 - 25 K.

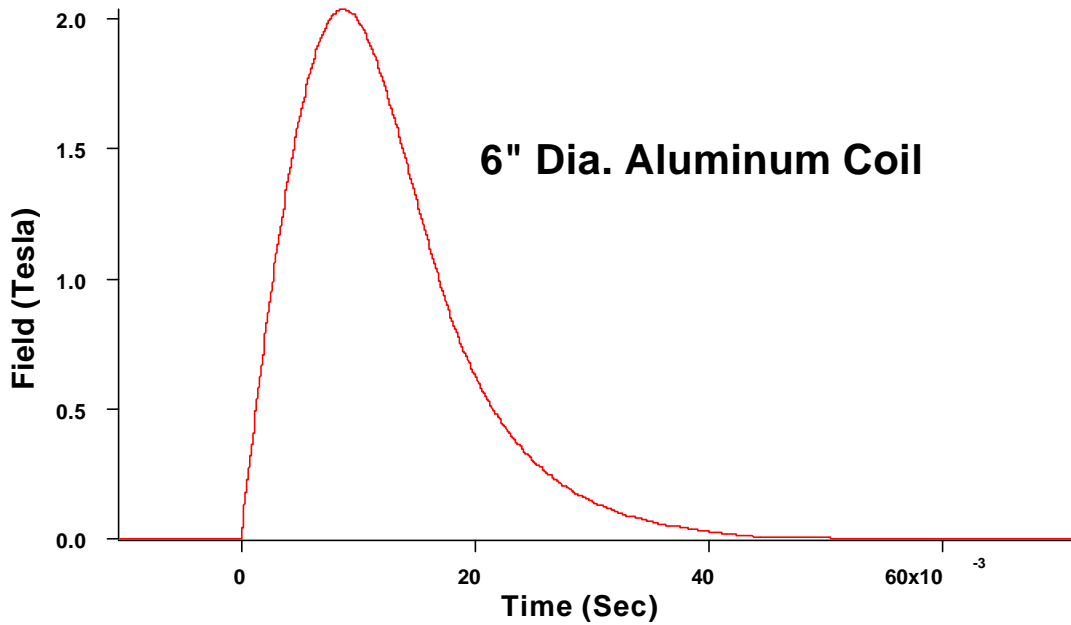
Aluminum Coil Design



Results of Measurement of Magneto-Resistance of Al Coil



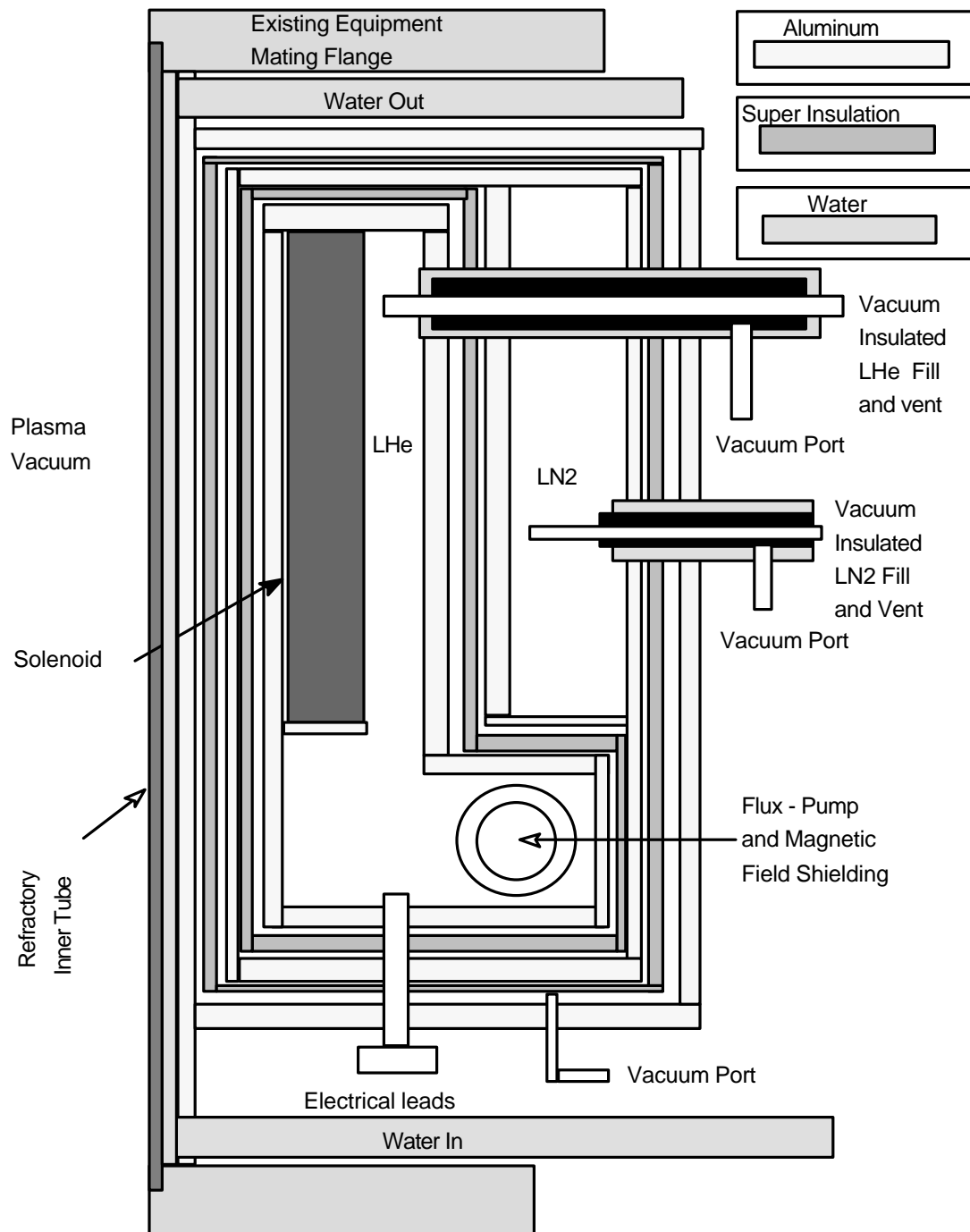
Completed Coil



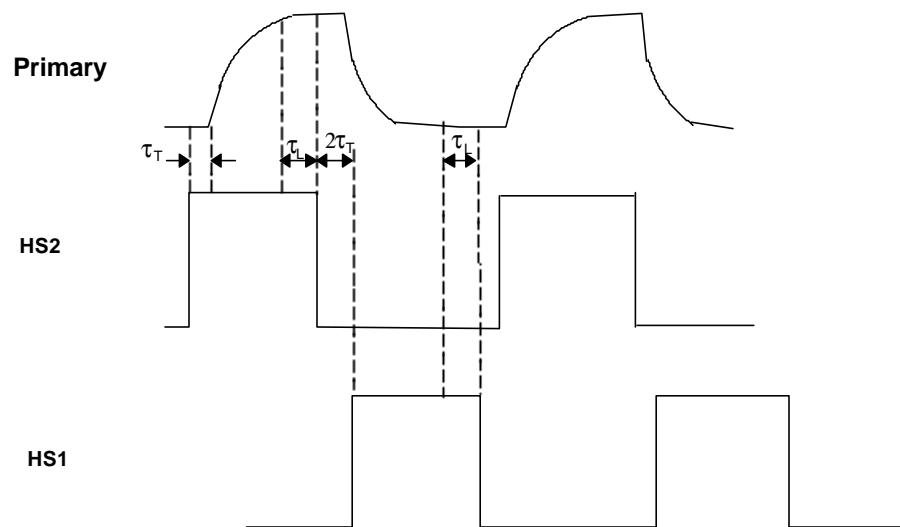
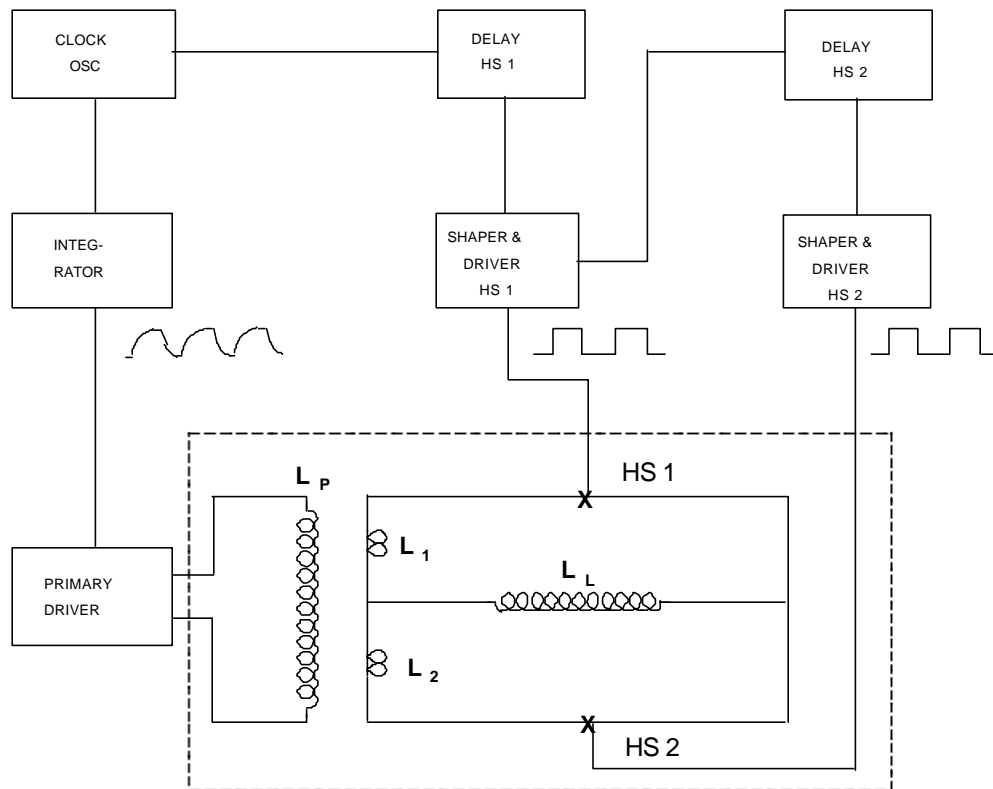
Test Specifications

1. **Charge Voltage = 3.21×10^3 Volts.**
2. **Maximum Current = 1.18×10^3 Amps.**
3. **Field per amp = 1.73 mTesla/Amp**
4. **Temperature Rise = 20 K from 77 K.**
5. **Cool down time after each pulse < 60 sec.**

Low Temperature Superconducting Coil Design

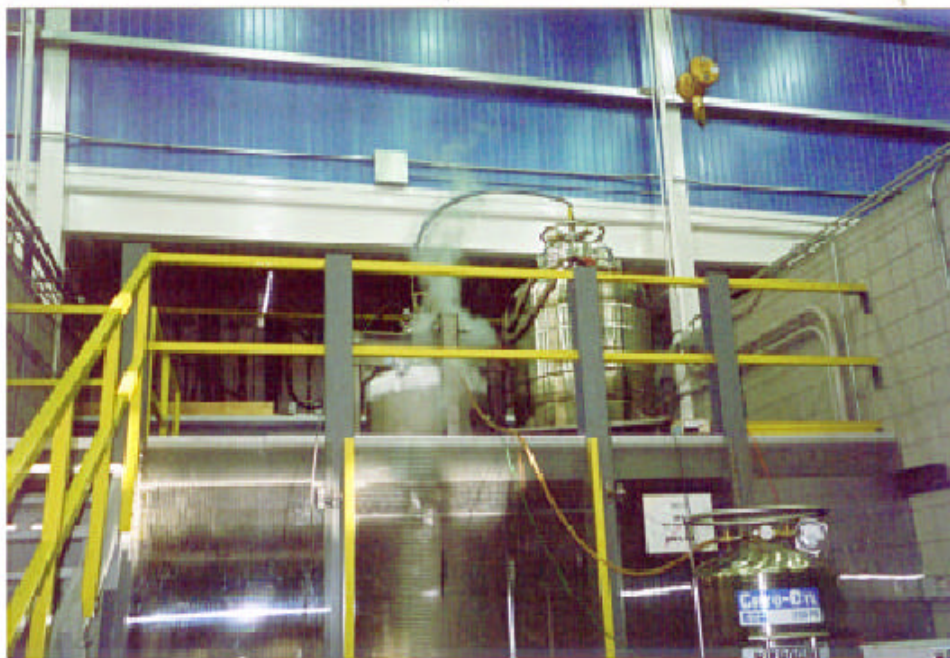


Flux Pump Schematic Diagram

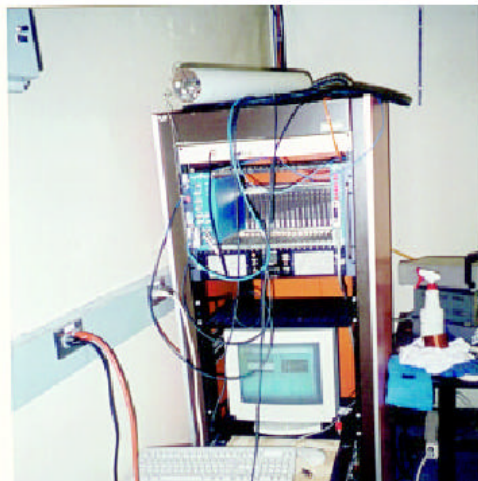


Al Coil Magneto-Resistance Tests

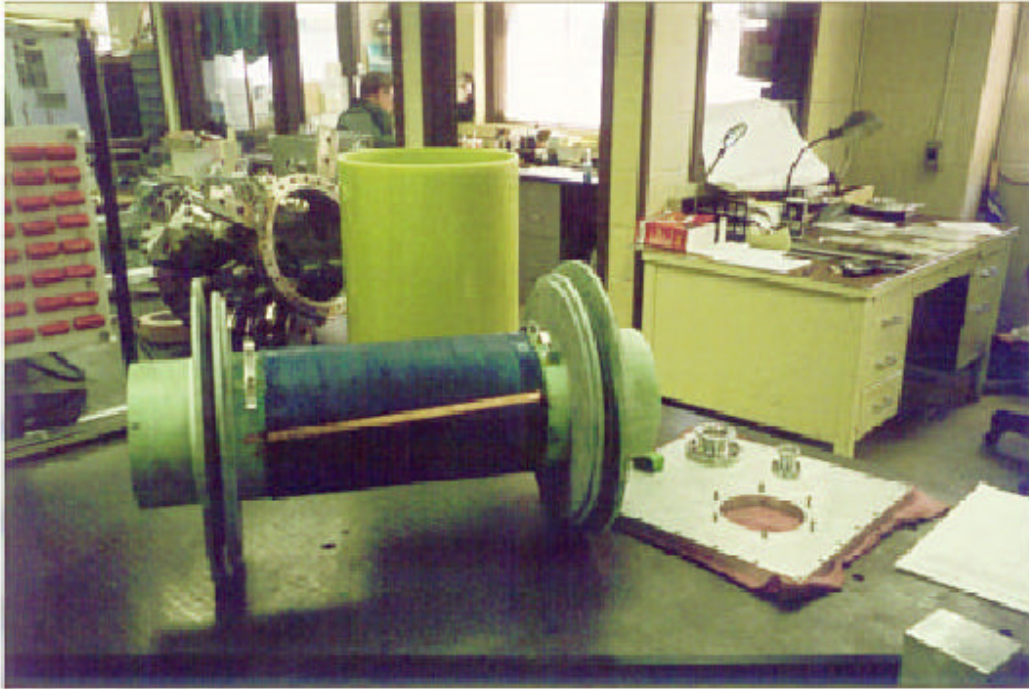
NHMFL - Tallahassee



Al Coil in Pulse Field Testing Facility NHMFL - Los Alamos



Al Coil with Dewar Parts LSU Machine Shop



Diminsions of Coil and Dewar

Coil - 6" Diameter by 11.5" Length

Dewar - 12.5" Diameter by 20" Length

Mass of Coil and Form - 3.69 Kg

**Mass of System (Excluding End Flanges
for laboratory system) - 15.58 Kg.**

Current Status

- 1. An Al Coil for Pulsed Fields to 2 tesla has been constructed and completely tested.**
- 2. A low temperature superconducting coil and associated cryogenics to produce 2 tesla in a 6' bore has been designed.**
- 3. A flux pump power supply has been designed.**
- 4. A High temperature superconducting coil and flux pump is planned for the future.**